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TECHNICAL
MEMORANDUM
ORO-T-1(CONARC)
CORG-FER-1

Vulnerability of the Infantry Rifle Company to the Effects of Atomic Weapons

Part I

by

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August 1955

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WORKING PAPER

This is a working paper of members of the technical staff of the Combat Operations Research Group, CONARC, in coordination with members of the Tactics Division concerned with ORO Study 63.1.

The objective of Study 63.1 is to design field tests and maneuvers in order to assist the Army in arriving at conclusions with respect to tactics, TO&Es, and weapons systems for atomic warfare. This paper, "Vulnerability of the Infantry Rifle Company to the Effects of Atomic Weapons," deals with one aspect of this objective. The findings and analysis are subject to revision as may be required by new facts or by modification of basic assumptions. Comments and criticism of the contents are invited. Remarks should be addressed to:

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FIELD DIVISION
CORG GROUP
Technical Memorandum ORO-T-1 (CONARC)
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FOREWORD

This memorandum consists of two parts, bound separately: a text and Appendices A to G. It is not expected that all readers of the text will require the appendices. The detailed data contained in the appendices can serve as the basis for further research on the vulnerability of infantry troops, making duplication of the field tests and extensive observation in this area unnecessary.

Appendix A is a descriptive scenario of the field test, including copies of all messages used to implement the maneuver along with topographic maps and overlay showing all situations and movements. Appendix B describes the various transformations of the basic exposure data used in the study, beginning with the original form of the data as it was recorded on film and including examples of the tabulations utilized in the reduction process. Appendix C is an analysis of the field-test data designed to produce estimates of the exposure of individuals in the tested company. Appendix D presents the questionnaire given to combat-experienced officers and designed to provide an independent estimate of exposure data and probable casualties for situations similar to those of the field test. Appendix E determines the casualty-producing parameters for exposure to various sizes of atomic weapons' bursts. Appendix F isolates four selected maneuver situations in the test and analyzes the results of atomic attacks on individuals in these situations. Appendix G terminates the memorandum with a detailed description of the techniques of testing utilized in this study.

ACKNOWLEDGMENTS

Test VULCO was one of the first controlled field experiments conducted by operations analysts for the Army. Without the help and cooperation of both civilian and military analysts and the school troops and members of the staff of The Infantry Center this test would not have been possible. The authors wish to thank especially the 2d Bn of the 30th RCT for its complete cooperation; F Co, 2d Bn, for its patience and energy in providing the best possible test data; and The Infantry Center for its logistic support of the test.

The authors also wish to acknowledge the cooperation of the following organizations and operations analysts who joined them in recording the test data; H. P. Griggs, C. J. Christianson, P. F. Dunn, R. B. Wing, and Drs. D. W. Meals, H. N. Hantzes, G. Harmse, J. R. Heverly, and W. H. Durfee of ORO; the Columbia Research and Development Corp, Columbus, Ohio, represented by W. A. Gunn, H. Cox, M. Hoffman, and D. McElhoes; the Signal Corps Evaluation and Analysis Group of Haller, Raymond and Brown, Inc., State College, Pa., represented by W. R. Bastian, W. T. Stevens, W. Burnette, J. Bogar, M. Kohler, W. Skagerberg, and J. Smith; Willow Run Research Center of the University of Michigan, Ypsilanti, Mich., represented by B. Harrison, C. Wing, B. Weinert, W. Minard, and L. Dillard; the officers and enlisted personnel of the 2d Sig Plat (Photo) and the 9440 TSU of HQ, Signal Corps Pictorial Center, Long Island City, N. Y.; and particularly the Army officers and civilian analysts of CORG whose complete cooperation is especially appreciated.

Finally, the authors wish to acknowledge the consultation of Miss Arla Weinert of ORO in designing a method of transferring the test data from film to punch cards; and to thank Sgts J. Jasco, E. M. Mull, and F. J. Smith of the 8575 AAU, and Cpl Barbara A. Kent of the 2124 ASU, Ft Monroe, Va., who were of great assistance in reading the photographs and preparing the punch cards; and Sgt Charles E. Shelby, Combat Developments Section, CONARC, Ft Monroe, who aided in the statistical analysis of the test data.

CONTENTS

CONTENTS (CONTINUED)

PROBLEM

To determine the vulnerability of an infantry rifle company to the effects of atomic weapons and to suggest techniques whereby vulnerability may be reduced without reducing combat effectiveness.

FACTS

There is a lack of quantitative data on the orientation and physical disposition of infantry troops as they accomplish their various missions on the battlefield. Such data are required to determine the vulnerability of troops to atomic attack. A tactical troop test in peacetime gives an approximation of troop behavior in combat.

DISCUSSION

It is considered most urgent that the Army be provided with an accurate measure of the casualties that infantry troops may suffer when fighting in a war in which both sides have the capability of employing atomic weapons on the battlefield. To acquire some of these data, a field experiment was designed and conducted by the Combat Operations Research Group. A full-strength TO&E infantry rifle company was put through a realistic series of tactical situations that included essentially all the maneuvers in which infantry troops are involved in combat, e.g., attack, defense, delaying action, withdrawal, etc. This test required 7 days to complete and covered an area of 30 sq miles. Sixty observers, both Army personnel and civilian analysts, recorded photographically the activity and degree of exposure of nearly every individual in the rifle company at approximately half-hour intervals. Each photograph was analyzed in detail. The data were transferred to IBM punch cards for sorting and printing and were summarized in tabular form. The percentage of company personnel having different degrees of protection from atomic effects was determined as a function of the type of action in which the company was engaged and also as a function of the job assignment of the personnel.

Estimates of the same sort of data on exposure of troops were also obtained by means of a questionnaire covering the same situations used in the field test. It was completed by 121 officers with combat experience, and although there was wide disagreement among individual respondents the mean values agreed closely with those of the field test.

In addition to giving information on the vulnerability of a rifle company to the effects of atomic weapons, this study attempts to quantify the effectiveness parameter of firepower and treats in detail the effects of atomic weapons on

the firepower of a rifle company. The data provided in this study also permit determination of the casualties in the company that would occur from any atomic weapon detonated in the vicinity. The scenario of the field test was examined from the point of view of the Red Commander, and four situations were selected where he could be expected to use atomic weapons against targets close enough to affect the company.

CONCLUSIONS*

1. Foxholes with heavy overhead cover constructed according to present doctrine provide a high degree of protection against atomic attack, but the time now required to prepare such positions is dangerously long.

2. It took about 1 ½ hr from the time of arrival in a defense area for the company to dig foxholes deep enough to provide emergency below-ground cover for the whole unit. During this time about 95 percent of the personnel was fully exposed.

3. Assembly areas took about 4 hr to prepare, during which time the percentage of men fully exposed dropped steadily from 100 percent down to a level of 10 percent for occupation of the completed area through the night.

4. Hasty defensive positions took about 3 hr to prepare, during which time the percentage of men fully exposed dropped steadily from 100 percent down to a level of 15 percent for occupation of the completed position through the night.

5. Deliberate defensive positions took about 12 hr to prepare, during which time the percentage of men fully exposed dropped steadily from 100 percent down to a level of 30 percent for daylight occupation or 15 percent for night occupation.

6. Reduction of preparation time by one-third will on the average reduce the percentage of men fully exposed by one-quarter.

7. Once a man's body is just below ground level the addition of overhead cover (up to a layer of logs and earth) offers more protection than does greater depth.

8. Foliage provides a high degree of thermal protection, but this is somewhat mitigated by the secondary blast effects from tree blowdown and fire.

9. Unit leaders were exposed up to four times as much as other personnel in the company.

10. The faces of troops in the open are randomly oriented except when troops are engaged in some obviously directional activity such as following a path or attacking. (There is little to be gained by placing a bomb at a particular azimuth with respect to a company fully exposed.)

11. The necessary functions of the rifle company occupying an assembly area or a position in light contact with the enemy can be carried out with 80 to 90 percent of the unit always under cover.

*Conclusions on position preparation refer to preparation when not in close contact with the enemy.

12. The data from the questionnaire and from the field test were in close agreement in respect to both times and exposures and offered a mutual validation for each other.

13. An appropriate combination of some or all of following techniques and equipment appears to provide means of reducing preparation time for positions by as much as one-half: (a) additional hand tools for position preparation; (b) improved entrenching tool; (c) power saws and pneumatic drills operated by jeep-mounted air compressors; (d) explosive charges designed for digging holes; (e) mechanical hole digger equipped with an auger or revolving scoops; (f) more transportation for infantry equipment; and (g) use of canvas overhead cover while digging positions, particularly weapons emplacements.

14. The following techniques and equipment appear to offer substantial improvement in the shielding of personnel: (a) invariable use of at least a light overhead cover such as canvas for all positions; (b) keeping all men fully clothed all the time; (c) keeping trucks covered when transporting personnel; (d) keeping equipment and weapons under cover when not in use; (e) use of field clothing re-designed to help protect areas of skin presently exposed; (f) emphasis on protection of unit leaders and their assistants; and (g) aided communications down to and within squads to obviate having unit leaders and messengers leave cover to communicate.

15. The changes in equipment and techniques as suggested in the foregoing conclusions should provide protection substantially greater than that now available. No further changes in tactics, doctrine, or equipment for the rifle company are foreseen for a war in which atomic weapons are used on the battlefield. The balance between protection and effectiveness is at present close to optimum; any effort toward added protection greater than that indicated in the above conclusions would reduce unit effectiveness below acceptable levels.

RECOMMENDATION

1. Efforts toward the reduction of infantry vulnerability to the effects of atomic weapons should be directed to reducing the time required to prepare positions rather than to improving the standard foxhole with heavy overhead cover.

VULNERABILITY OF THE INFANTRY RIFLE COMPANY
TO THE EFFECTS OF ATOMIC WEAPONS

INTRODUCTION

The mission of the Combat Operations Research Group is to investigate changes in Army organization, equipment, and doctrine needed as a result of the probable use of atomic weapons by both sides in any future war. The problem is being approached in two ways: by analysis and experimentation. This study presents the results of the first of a series of field experiments being developed to provide data for analysis.

The infantry soldier is considered to be highly vulnerable to the effects of atomic weapons. This first test was designed to assess his vulnerability as he performs various tasks on the battlefield. It was accomplished by developing a tactical situation in which a hypothetical infantry division was given a defensive mission, with an actual rifle company of this hypothetical division as the test unit. The field experiment had the code name VULCO and was conducted at Ft Benning, Ga., during the period 8–18 Feb 54. It was designed to provide two categories of information: exposure of troops to atomic weapons effects and data on time required to accomplish tasks such as digging in, setting up weapons, etc.

The purpose of this memorandum is to present the statistical data collected during Test VULCO and to discuss the attrition to which the rifle company would have been subjected if atomic weapons were employed on the battlefield. On the basis of the data certain changes in techniques and equipment are suggested that could markedly improve individual and unit protection from the effects of atomic weapons.

In order to provide a check on the validity of the field-experiment results and to fill gaps in information that were impracticable to obtain in the field experiment, a questionnaire was developed that followed the situation and time sequence of the field test. Questions on the extent of exposure of troops in 29 specific situations and on the time required to accomplish specific tasks were included in the questionnaire, which was completed by 121 Army officers who answered it on the basis of their combat experience. It was found that data obtained from the questionnaire agreed closely with that obtained in the experiment itself.

The field experiment was designed to provide data on several tactical situations in which a rifle company may be involved in combat. Figure 1 is a schematic diagram of the over-all regimental situation, showing the various positions of the hypothetical regiment of which the tested company was a component and giving the tactical situations and the time spent in these situations.

Figure 1 shows that on D-Day the company, occupying Position 0—the assembly area—had not yet been in contact with the enemy. In Positions 1 and 2—the main and alternate defensive positions—the enemy approaches and comes

in contact with company patrols by nightfall on D+1. An enemy attack on the morning of D + 2 drives the company into its alternate position. Hypothetical forces counterattack, permitting the company to reoccupy its main position, where it remains until the evening of D + 2. It then occupies Position 3—a blocking position as battalion reserve—through the night of D + 2–D + 3; in the morning of D + 3 the battalion uses the company for counterattack to cover its own withdrawal. Position 4 represents a hasty defensive position; it was prepared

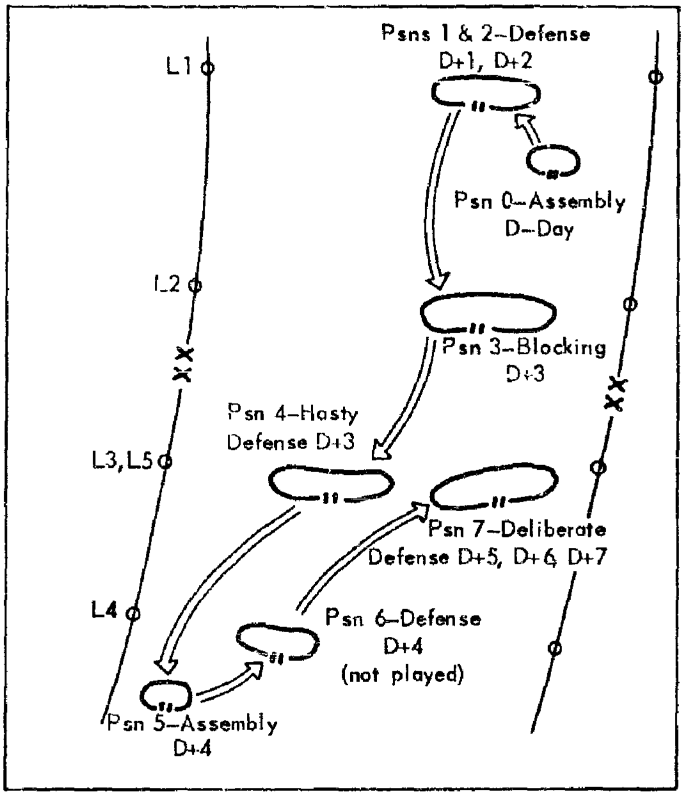

Fig. 1—Field-Test Situations, Showing Hypothetical Battalion of Which Tested Company Was a Part and Including Time and Action Sequence

during the afternoon of D + 3 and the company withdraws from it before dark to Position 5—an assembly area—located behind the division MLR and occupied through the night of D + 3–D + 4. Position 6, not played in the field test since there was time out through D + 4, represents the defense of a position seized by counterattack. Deliberate defense was started on the morning of D + 5—Position 7. The enemy was driven north by hypothetical forces and did not come into contact again until the evening of D + 6. The play ended D + 7.

The data were collected by teams of observers controlled by a chief observer and equipped with both still and motion-picture cameras. These teams followed the rifle company through its various tactical situations and recorded

on film at approximately half-hour intervals the degree of exposure and the activity of each man in the company.

The operations of the rifle company were controlled as they would be controlled by the battalion in combat. Battalion headquarters was represented by a skeleton staff through which orders were channeled from test headquarters to company headquarters. Tactical disposition of company components was left to the discretion of the CO, but with the usual amount of supervision by battalion. Future events were not known to the CO except for the general over-all plan of operations of the regiment; the time schedu. was controlled by test headquarters, which relayed instructions to battalion.

EXPOSURE OF RIFLE COMPANY TO EFFECTS OF ATOMIC WEAPONS

Exposure Categories for Field Test

The photographic data from the field test were analyzed to determine percentages of individuals of the test company in various exposure categories during the test period. The exposure categories were developed through a consideration of both the bodily attitude of the individual, the depth of his foxhole, and the amount of cover over him.

Initially the following all-inclusive list was made of categories of exposure thought most likely to be found for the infantryman in combat:

(a) Standing in the open or in a shallow foxhole
(b) Sitting, kneeling, or crouching in the open
(c) Prone in the open
(d) Prone in the open, but completely covered with sleeping bag or shelter half
(e) Sitting, kneeling, or crouching in a shallow foxhole
(f) Standing in a deep foxhole
(g) Prone in an open shallow foxhole
(h) Sitting, kneeling, or crouching in an open deep foxhole
(i) Prone in an open deep foxhole
(j) Prone in shallow foxhole and covered with sleeping bag, shelter half, or light branches
(k) Sitting, kneeling, or crouching in a deep foxhole and covered with sleeping bag, shelter half, or light branches
(l) Prone in deep foxhole and covered with sleeping bag, shelter half, or light branches
(m) Sitting, kneeling, or crouching in deep foxhole that is covered with heavy logs and earth
(n) Prone in deep foxhole that is covered with heavy logs and earth

This list was shortened by combining those categories with nearly the same vulnerability to the effects of atomic weapons. The final list used in this study resulted in:

Category 1—Body mostly above ground, attitudes (a), (b), and (c)
Category 2—Body mostly above ground and completely covered with sleeping bag or shelter half, attitude (d)

Category 3—Body mostly or entirely just below ground level (with or without light overhead cover of branches),* attitudes (e), (f), (g), and (h)

Category 4—Body mostly or entirely just below ground level and completely covered with sleeping bag or shelter half, attitudes (j) and (k)

Category 5—Body mostly or entirely just below ground level and completely covered with heavy logs and earth, attitude (m)

Category 6—Body entirely well below ground level (with or without light overhead cover of branches),* attitudes (i) and (l)

Category 7—Body entirely well below ground level and completely covered with heavy logs and earth, attitude (n)

Analysis of the VULCO photographic data showed that it was not possible to distinguish between men prone—attitude (n)—and those sitting, kneeling, or crouching—attitude (m)—in a deep foxhole that is covered with heavy logs and earth. As a result, exposure categories 5 and 7 were regrouped into:

Category 8—Body entirely below ground level and completely covered with heavy logs and earth, attitude of soldier unknown

Categories 2 and 8 were used so slightly that they are henceforth often omitted.

Exposure of Troops in Field Test Compared with Estimates from Questionnaire Data

The percentages of the company in each of categories 1, 3, 4, and 6 throughout the test are shown in Fig. 2 in which the curves are smoothed somewhat by plotting points each hour instead of each half-hour and by the omission of all points during mess periods, which were nontactical in VULCO. In order to determine the extent to which the information sought by the field test might be susceptible to estimation by experienced officers, a questionnaire was designed to cover the major aspects of time and exposure for the infantry company in a variety of situations similar to those used in the field test. It was given to 121 officers with combat experience, and the average of the resulting estimates was found to agree closely with the field-test data (see category 1).

Two main relations between exposure and time are apparent. From Fig. 2 it appears that initially (at 1400, D-Day) all troops were in the open (category 1) and that by 2300, D-Day, as their assembly area was completed, they had changed almost entirely to positions just below ground and covered with shelter halves (category 4). Such periods of regular change from one category to another have been called "trend periods" and are characterized by a smooth transition from one degree of exposure to another.

From about 0900, D+1, to 1700, D+2, there is a relatively long period when about 25 percent of the company was mostly or entirely just below ground level (category 3). This was a period of preparation and occupation of a defensive position, including a brief withdrawal from and return to it. Such periods of more or less constant exposure have been called random periods and are char-

*Exposure categories 3 and 6 do not specify whether there is or is not light overhead cover. In both cases the additional protection offered by light branches overhead was considered small in comparison to the differences in protection between categories. However, these are broad categories and there is no intention to imply that this sort of cover is unimportant.

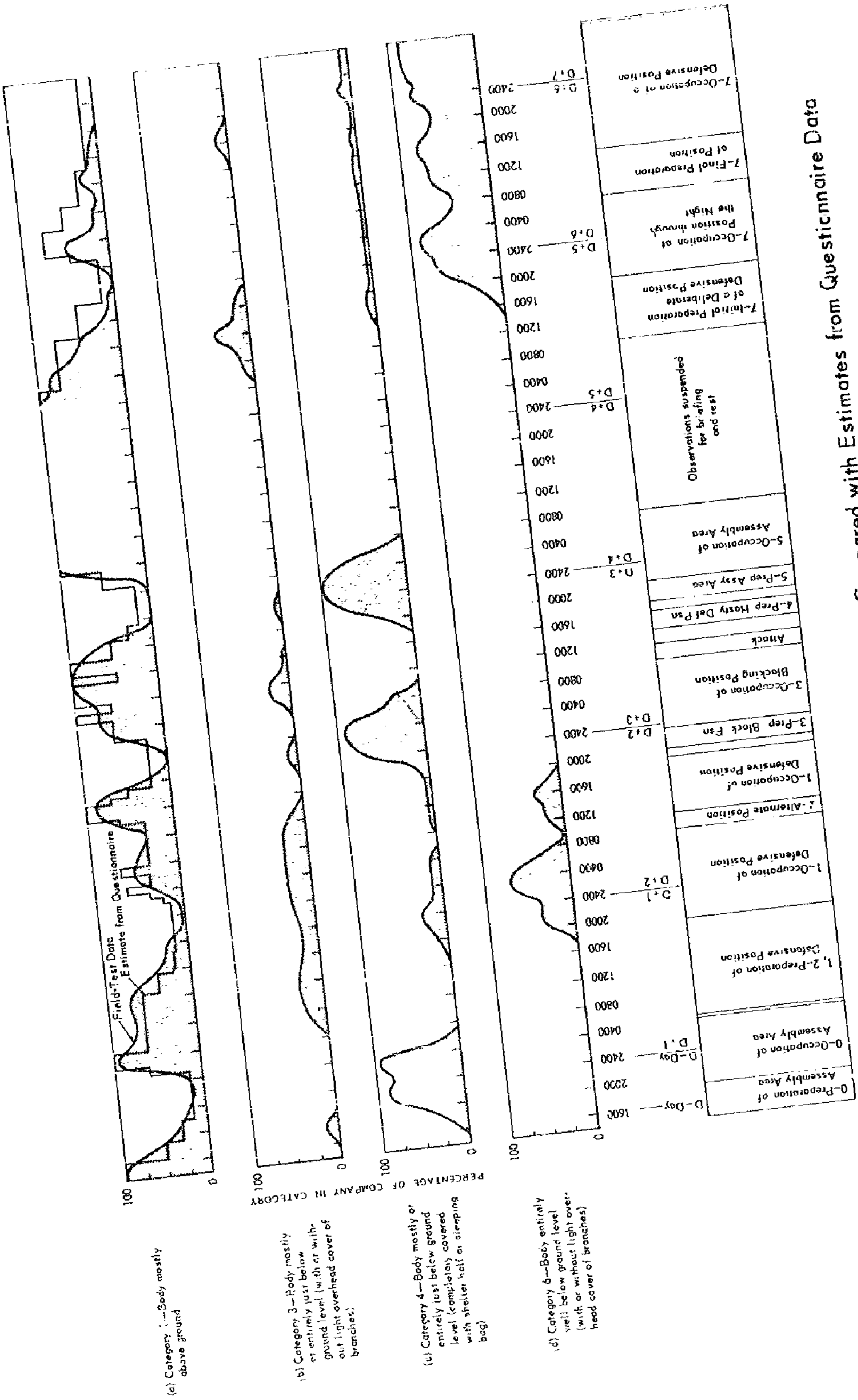

Fig. 2—Exposure of Troops throughout Field Test Compared with Estimates from Questionnaire Data

acterized by relatively constant exposure with small fluctuations. As might be expected, definite trends in the exposure categories appeared whenever the company moved into a new position; random periods characterized the occupation of a prepared position.

When an infantry company moves into and prepares an assembly area considerably to the rear of the MLR, approximately 4 hr elapse before a large percentage of the company (about 70 percent) can complete dug-in positions that will protect them from the effects of thermal radiation. (Thermal obscuration from the surrounding foliage when available may ameliorate this estimate.) Moreover, these positions do not afford protection from gamma radiation since the foxholes are shallow and do not have heavy overhead cover. If protection from thermal radiation is given top priority in an assembly area, then troops could increase their protection by (a) putting up their shelter halves immediately on arrival in the area and (b) digging shallow foxholes or slit trenches only under this protective cover. (A lightweight thermal-resistant covering might be developed that could be used to cover troops constructing mortar and 57-mm recoilless-rifle emplacements.)

One purpose of this questionnaire was to determine if this relatively inexpensive technique could satisfactorily be used to collect data of this kind. The agreement of the "polling" results with the field test indicates that a questionnaire given to a large number of experienced officers can give results comparable to those obtained in measurements in the field. The questionnaire resulted in a description of exposure in 29 specific situations typical of the rifle company. Associated time durations were estimated, as well as casualties by number and duty assignment.

Summary of Data for Type Positions (Assembly Area, Hasty Defensive Position, Deliberate Defensive Position)

Three types of positions occupied most of the time of the company. The field-test and questionnaire data are combined in Table 1 to show preparation time and exposure level during occupation of these three positions: assembly area, hasty defensive position, and deliberate defensive position. Each occurrence of a situation is given equal weight whether it came from the field test or the questionnaire.

The field-test data in all cases show a steady drop down from 100 percent of the men fully exposed during the period of preparation of every type of position. Even in the preparation of the longest deliberate position, which took all the daylight hours of 1 day and the morning of the next, there was an average of 70 percent exposed; however, the steady drop was apparent from 100 percent down to the level for occupation of the prepared position.

Assembly areas took about 4 hr to prepare with the percentage of men exposed dropping during this time from 100 percent down to a level of 10 percent for occupation of the area through the night. Preparation of a hasty defensive position required an average of 3 hr; exposure dropped from 100 percent to a night occupation level of 15 percent. Preparation of a deliberate defensive position took an average of 12 hr with a steadily dropping percentage of men exposed that averaged about 70 percent over the 12 hr. The level of exposure for daylight occupation of this type of completed position was 30 percent; for night occupation the exposure was 15 percent.

TABLE 1

SUMMARY OF FIELD-TEST AND QUESTIONNAIRE DATA FOR TYPE POSITIONS

Type of position	Field-test[a] and questionnaire positions	Preparation time, hr:min	Mean percentage of company exposed[b]
Assembly area			
Preparation	Field test:		
	1430–1900 D-Day	4:30	
	1800–2200 D+3	5:00	
	Questionnaire:		
	Part IC	3:13	
Night occupation	Field test:		
	2200–0500 D,D+1		12
	2300–0500 D+3, 4		5
	Questionnaire:		
	Part IF		14
Hasty defensive position			
Preparation	Field test:		
	2030–2300 D+2	2:30	
	1330–1630 D+3	—[c]	
	Questionnaire:		
	Part IIA	3:45	
	Part IIIC	3:15	
Night occupation	Field test:		
	0100–0459 D+2, 3		5
	Questionnaire:		
	Part IIC		22
Deliberate defensive position			
Preparation	Field test:		
	0700–1700 D+1	10:00	
	0900–1300 D+5, 6	16:00[d]	
	Questionnaire:		
	Part IVC	8:45	
	Part VC	13:30	
Day occupation	Field test:		
	1300–1700 D+2		36
	1300–1730 D+6		11
	Questionnaire:		
	Part VIB		34
	Part VD		29
Night occupation	Field test:		
	2000–0500 D+1, 2		15
	1900–0600 D+5, 6		12
	1900–0600 D+6, 7		8
	Questionnaire:		
	Part VIIB		17

[a]Periods of messing were omitted for field-test data.

[b]See Fig. 2 for preparation exposure percentages.

[c]Preparation was not completed in the 3 hr the company was in this position.

[d]12 hr from 1800 to 0600 were omitted because troops did not work on preparation of this position during the night.

At night in a prepared assembly area about 10 percent of the troops are exposed; at night in either kind of defensive position about 15 percent are exposed. The exposure during the day of 30 percent in a prepared defensive position is higher than that at night, as expected, but it is too high for satisfactory defense in an atomic war. An indication that it need not always be this high is found on the afternoon of D + 6 in the field test when exposure averaged only 11 percent for 4 ½ hr.

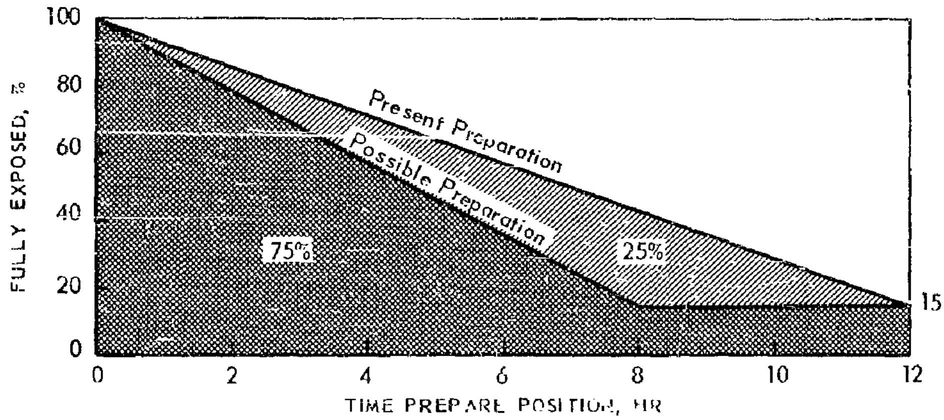

Fig. 3—Approximate Savings of One-fourth of Fully Exposed Personnel by Reducing Preparation Time by One-third for Preparation of a Deliberate Defensive Position Prior to Night Occupation of It.

It was also found that it takes about an hour and a half with exposure averaging 95 percent for troops to dig foxholes deep enough to provide emergency below-ground protection for the entire company.*

It is of interest to obtain an estimate of the long-run reduction in the percentage of men fully exposed if preparation times are reduced. This savings of men fully exposed is proportional to the reduction of the total area under the exposure-time curve. Figure 3 shows that in the case of preparation of a deliberate defensive position, where completion of the position is followed by occupation through the night, the original total area is under the curve running from 100 percent at 0 hr down to 15 percent at 12 hr. Reducing the time by one-third to 8 hr gives a new area; the difference between the two areas represents a savings of 25 percent of men fully exposed. Reducing preparation time by one-third for the preparation of a hasty defensive position produces a similar savings of 25 percent and for an assembly area of 27 percent when these preparations are followed by night occupation.

This reduction by approximately one-quarter of the men fully exposed, obtained by a reduction of preparation time by one-third for each type of position, represents a substantial improvement and justifies the expenditure of considerable effort to reduce preparation times.

Exposure Differences between Subgroups in Field Test

The company personnel were divided into subgroups primarily according to differences in their weapons. In order of decreasing vulnerability to atomic weapons effects they ranked (a) company and weapons platoon headquarters,

*Emergency cover is provided by even a shallow hole that will permit a man to get entirely below ground level in case of need; e.g., a partly completed foxhole.

(b) mortar sections, and (c) 57-mm recoilless-rifle sections, rifle platoon headquarters, rifle squads, and weapons squads. The first group is exposed up to four times as much as the other two. Since the command and intelligence functions are concentrated in the most exposed group and since these functions assume added significance following atomic attack, means are urgently needed to reduce their vulnerability.

Exposure Differences between Subgroups in Questionnaire Data

For each of the 29 situations in the questionnaire separate exposure estimates were made for six subgroups, which were identified primarily on the basis of level of command. These were (a) 1 CO; (b) 1 ExO; (c) 4 platoon leaders; (d) 20 section and squad leaders; (e) 20 company headquarters personnel; (f) 151 others. They were grouped according to their differences in exposure averaged over all situations covered in the questionnaire. Most exposed are the platoon leaders; next, the CO, ExO, and section and squad leaders; and finally, the company headquarters personnel and others (mainly members of rifle and weapons platoons).

This ranking may be considered consistent with the field-test results when the differences in methods of subgrouping are taken into account.

Troop Orientation

The hypothesis that troops fully exposed are facing in random directions was tested. Eight field-test situations were selected for analysis and it was found that troops fully exposed were indeed randomly oriented except when attacking or doing a job that required them to utilize a particular path between two positions. It is to be presumed that they would also show a directionality of facing when engaged in close combat with the enemy and when marching. Otherwise troops fully exposed occupying a position exhibited no tendency to face the front or direction of possible attack.

Obscuration of Thermal Radiation by Foliage

The majority of casualties suffered from the effects of atomic weapons will probably be caused by thermal radiation. This is true for the greater part of the range of weapon yields, from 5 kt to 5 Mt. These casualties occurred even when the troops were in shallow foxholes. It was felt that a great many of these casualties could be avoided if the advantage of natural shading were taken. Therefore a study was made of the protection that natural shading would provide to troops on the battlefield.

The data for this study were obtained by modifying a K-20 aerial camera for use on a tripod. Panoramic photographs of the surrounding terrain were made, centered on previously occupied positions. These photographs were made by rotating the camera 360 deg of azimuth. The percentage of thermal obscuration that the surrounding foliage afforded to the troops as they occupied the positions during the field test was determined from these photographs.

The method of determining obscuration entailed the use of a light box with a mask fixed to the ground glass giving a horizontal reference line and a fireball image to film scale for the various sizes of weapons used in this report. The film negative was then placed over the mask and the area of obscuring material (leaves, branches, and opaque objects) was measured with a

Fig. 4—Examples of 24 and 25 Percent Obscuration of Thermal Radiation by Foliage
(Left circle, 24 percent; right circle, 25 percent)

planimeter. Since the total fireball area was known the percentage of the thermal radiation obscured was determined. Figures 4–6 show typical forestation in the Ft Benning area with the average-sized fireball superimposed on the photograph. The foliage area obscuring the radiation has been determined by the method described and examples are shown of various percentages of obscuration.

In determining the mean fireball size to be used in the obscuration measurements an average was taken of atomic bombs in the range of 1 kt to 25 Mt exploded at distances from the company at which thermal radiation effects were the predominant casualty-producing agent.

The type of statistical information required is an accumulative form of the frequency distribution of the occurrence of various percentages of obscuration at the various tactical positions involved in the troop test. Figure 7 shows this frequency distribution for the four positions studied. With the exception of the first delaying position the positions selected in the scenario of the test were relatively heavily wooded. As an example of the degree of obscuration afforded by the foliage at Ft Benning, it can be seen from Fig. 7—the assembly area—that there is a 0.65 probability that there will be greater than 50 percent thermal obscuration.

Tree Blowdown

The peak blast overpressure required to produce combat ineffectives in the various exposure categories is compared to the percentage of tree blowdown expected at these blast levels in the accompanying table:

Exposure category	Blast pressure, psi	Blowdown, %[1]
1	8-11	99
2	12	99
3	10-15	100
4	15	100
6	20	100
8	30	100

It can be seen that personnel who are subject to casualties from blast will be well within the area of complete blowdown of the trees. This situation is highly significant from a mobility point of view. For example, if troops are in a defensive position in exposure category 8 (body entirely below ground and completely covered with heavy logs and earth) the required overpressure to produce a combat ineffective is 30 psi. An atomic explosion occurs that produces much less overpressure at the troop positions than 30 psi. Although the troops do not suffer combat ineffectives from direct blast or thermal or gamma radiation, their positions could be well within the area of complete blowdown. Many bunkers would be collapsed by blown-down trees and openings sealed off by large limbs and trunks with a consequent immobilization of the unit until the area has been cleared. It may take up to several hours to accomplish this task with the result that this unit is effectively removed from action during that time.

Fig. 5—Examples of 83 and 50 Percent Obscuration of Thermal Radiation by Foliage
(Left circle, 83 percent; right circle 50 percent)

Fig. 6—Examples of 54 and 61 Percent Obscuration of Thermal Radiation by Foliage
(Left circle, 54 percent; right circle 61 percent)

ATOMIC WEAPONS EFFECTS CRITERIA

The purpose of this section is to discuss the atomic weapons effects criteria used for analysis of the effects of atomic weapons on infantry troops. The criteria presented here should also be of interest and value in other studies of the vulnerability of military personnel to atomic weapons.

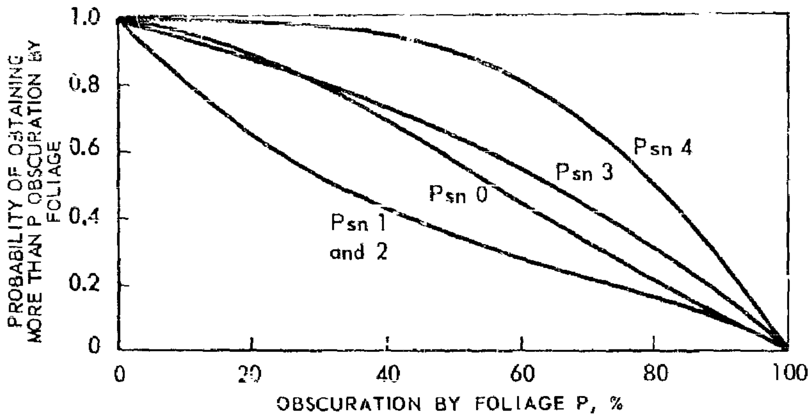

Fig. 7—Probability of Obscuration by Foliage in Position 0 (Assembly Area) and Positions 1, 2, 3, and 4 (Defensive Positions)

Methodology

For purposes of this analysis, a combat ineffective is defined as a soldier who requires evacuation from the unit (company) within a 2-hr period. It should be possible, then, to specify the parameters—thermal radiation, peak blast overpressure, and gamma radiation—that would cause a soldier to become a combat ineffective within 2 hr. These parameters depend on (among other things) the attitude, attire, and location of a soldier at the time of detonation.

Establishing Casualty-Producing Parameters for Exposure Categories

The analysis requires assignment of casualty-producing parameters for each exposure category. The thermal, blast, and gamma values selected indicate the levels at which a soldier is likely to become combat ineffective. Unfortunately, probability distributions do not presently exist for all the exposure categories; consequently, estimates had to be made utilizing whenever possible the latest available information on the effects of atomic weapons on personnel. Chiefly because of the uncertainties in the effects data with regard to personnel it was felt that a single value, or a narrow range of values, could be used to express the parameters that make a combat ineffective for each exposure category. It is believed that the values chosen provide between a 0.7 and 0.9 probability of producing a combat ineffective in each category. In Table 2 the composite exposure categories and the associated values of thermal radiation, blast overpressure, and gamma radiation are shown.

REDUCTION IN EFFECTIVENESS OF RIFLE COMPANY

Firepower

In order to assess the reduction of effectiveness of the infantry company attention has been focused on the firepower aspect of effectiveness. The concept of the term "firepower" used in this memorandum consists of two parts: firepower capability, and firepower effectiveness. Firepower capability is measured by a tabulation of the weapons system of an infantry rifle company;

TABLE 2

EXPOSURE CATEGORIES AND EFFECTS VALUES FOR COMBAT INEFFECTIVENESS[a]

Exposure category	Description	Effects values for combat ineffectiveness		
		Thermal,[2] cal/sq cm	Blast, psi	Gamma, r, 2 hr
1	Body mostly above ground	20	8–11	800
2	Body mostly above ground and completely covered with sleeping bag or shelter half	70	12	800
3	Body mostly or entirely just below ground level (with or without light overhead cover of branches)	40 (20)[b]	10-15	1000–1600 (800)
4	Body mostly or entirely just below ground level and completely covered with sleeping bag or shelter half	70	20	1000–1600 (800)
6	Body entirely well below ground level (with or without light cover of branches)	200 (20–70)	20	8000 (800)
8	Body entirely below ground level and completely covered with heavy logs and earth	No limit[c]	30	No limit[c]

[a]Categories 5 and 7 omitted (see section on exposure categories).
[b]Numbers in parentheses apply when foxholes do not provide shadowing.
[c]For practical purposes.

i.e., each type of weapon, the number of each type of weapon, and the protracted (averaged over many months) rate of fire in combat of each type of weapon (based on actual combat experience). Firepower effectiveness is measured by estimated damage effects on the enemy's target complex (including type and location of targets and accuracy and lethality of weapons) as modified by such linking factors as weather, terrain, and range. Table 3 illustrates this concept by showing the relative distribution of the elements of the firepower

concept as they appear on the battlefield. Firepower capability will be analyzed and then related to effectiveness by means of estimates made by experienced officers.

Firepower Capability. The term "firepower capability" refers to the number and type of weapons in an infantry rifle company and the protracted

TABLE 3

ELEMENTS OF FIREPOWER CONCEPT APPEARING ON THE BATTLEFIELD

Capability, weapon system	Effectiveness	
	Intervening variables	Target complex
Type of weapons	Terrain	Types and locations of targets
Quantities of weapons	Weather	Accuracy of weapons
Rates of fire of weapons	Range of weapons	Lethality of weapons

rate of fire of these weapons. The following weapons are found in a full-strength infantry rifle company:

US carbine, cal .30 M2	29
Browning machine gun (LMG), cal .30 M1919A6	6
Browning machine gun, cal .50 HB M2	1
Grenade launcher M7A2	37 or 46
Rocket launcher, 3.5-in. M20 (ATRL)	3
Mortar, 60-mm M19 on mount M5	3
Automatic pistol, cal .45 M1911A1	30
Rifle 57-mm M18A1	3
Browning automatic rifle, cal .30 M1918A2 (BAR)	18
US rifle, cal .30 M1	110
US rifle, cal .30 M1C Sniper	9
Hand grenade	—
Bayonet	—

Each of these weapons was reviewed in terms of its tactical usage and its contribution to the firepower capabilities to the company. Those weapons that could be classed primarily as accessory, supplementary, or for individual self-defense were eliminated from the analysis. The carbine and the pistol, for example, were considered to be primarily for the self-defense of the individual carrying them. The .50-cal machine gun is frequently mounted on a vehicle and may be used as an antiaircraft or support-fire weapon; consequently, it is not used primarily for front-line combat. The hand and rifle grenades and the bayonets were regarded as accessory weapons that are very important but yet do not really fit in the classification of primary front-line weapons. In this analysis, then, it is assumed that only those weapons that comprise direct assault fire in normal tactical situations are significant contributors to the com-

pany's firepower capabilities. These weapons are:

US rifle, cal .30 M1 and M1C	119
Browning automatic rifle, cal .30 M1918A2 (BAR)	18
Browning machine gun, cal .30 M1919A6 (LMG)	6
Rocket launcher, 3.5-in. M20 (ATRL)	3
Rifle, 57-mm M18A1	3
Mortar, 60-mm M19 on mount M5	3

The above six weapons were then placed into two groupings, depending on the type of projectile used with each weapon: "A," slug projectile weapons; and "B," explosive projectile or area weapons. Group "A" consists of the rifle, the

TABLE 4

WEAPON CAPABILITIES WITHIN EACH OF TWO GROUPS

Weapon	No. wpn in Co	Rd/day/wpn, protracted	Capability index, rd/day
Group A			
US rifle, cal .30 M1 and M1C	119	6.0	714
Browning automatic rifle, cal .30 M1918A2 (BAR)	18	20.0	360
Browning machine gun, cal .30 M1919A6 (LMG)	6	50.0	300
Total	—	—	1374
Group B			
Rocket launcher, 3.5-in. M20 (ATRL)	3	1.5	4.5
Rifle, 57-mm M18A1	3	3.0	9.0
Mortar, 60-mm M19 on mount M5	3	5.0	15.0
Total	—	—	28.5

BAR, and the LMG. Group "B" consists of the 3.5-in. ATRL, the 57-mm recoilless rifle, and the 60-mm mortar. Each slug projectile weapon was considered to have equal capability per round with others in its own group. (It should be remembered that range will be accounted for later in relating firepower capability to effectiveness.) The explosive projectile weapons are also assumed to have equal capability per round for comparison within the area weapon group. No attempt is made at this point to relate the capability of the rounds of Group A weapons with that of Group B weapons.

In Table 4 the six basic company weapons are listed in their particular groupings. Current TO&E values were used for the quantity of each type of weapon in the company. The rate of fire for each weapon was selected from FM 101-10,[3] in which the number of rounds per day per weapon is shown for a protracted period; i.e., through many types of situations as determined from World War II experience. These figures actually indicate estimated expenditures of ammunition. It is believed that this type of estimate is a more reliable guide to actual rates of fire over a protracted period than would be, for example, the maximum or sustained rates of fire or the basic load for each weapon. It is assumed that for future engagements the relative rounds per weapon per unit time would remain substantially the same. The product of the number of

weapons of a particular type—the protracted rate of fire for that weapon—is then used as an index of the firepower capability of that type of weapon in its own group. The sum of the three capability indices in each group yields the total capability index of that group.

Relating the firepower capability of each weapon group to the unit's firepower effectiveness is complex, and was done on the basis of opinions of experienced officers.

TABLE 5

CONTRIBUTION OF WEAPONS TO TOTAL FIREPOWER EFFECTIVENESS

Weapon type	No. wpn in Co	Contribution to total firepower effectiveness, %	
		Type	Weapon
Group A			
US rifle, cal .30 M1 and M1C	119	31.18	0.26
Browning automatic rifle, cal .30 M1918A2 (BAR)	18	15.72	0.87
Browning machine gun, cal .30 M1919A6 (LMG)	6	13.10	2.18
Group B			
Rocket launcher, 3.5-in. M20 (ATRL)	3	6.32	2.11
Rifle, 57-mm M18A1	3	12.63	4.21
Mortar, 60-mm M19 on mount M5	3	21.05	7.02
Total	—	100.00	—

Firepower Effectiveness. A questionnaire was presented to 19 officers assigned to CONARC in an attempt to obtain a valid relation between the firepower capabilities of the two main groups of infantry rifle company weapons and the unit's total firepower effectiveness. The officers selected for this purpose were mostly infantry commanders (66 percent) and all the officers had had World War II combat experience. The officers were asked to rate on a scale of 100 the contribution of each group of company weapons to the over-all firepower effectiveness of the unit.

The results of the questionnaire were in surprisingly good agreement and favorable comments were received concerning the selection of the basic weapons and the choice of groups. The consensus was that the group A weapons comprised 60 percent and the group B weapons contributed 40 percent of the infantry rifle company's firepower effectiveness. Using these ratings the capability indices in the last column of Table 4 were related to firepower effectiveness. Then the share each type of weapon had in the over-all firepower effectiveness was estimated. By dividing these values for each weapon type by the number of those weapons in the company, the contribution of each weapon was obtained. These results are shown in Table 5.

The high contribution of the machine gun to the firepower effectiveness of group A weapons is considered reasonable since, when establishing the percent contribution of all of the slug projectile weapons, the use of the machine

gun in the role of the base of fire, lethality, shock action, etc., was taken into consideration. The values shown in the last column of Table 5 will later be used in estimating the degradation in firepower effectiveness caused by atomic explosions.

The validity of using a questionnaire to relate firepower capability with effectiveness is subject to question; however, at this writing, no other satisfactory expedient is apparent.

Examples of Attrition in Selected Situations

Four situations have been extracted from the scenario of the test that are illustrative of the effect of atomic weapons employed in the area of the company. These are summarized here.

Example 1. The first example illustrates the situation in which the rifle company was in assembly prior to moving into a defensive position. A 550-kt weapon was detonated 4300 yd from the company. There was a total of 30 survivors (15 percent of the company) with a 57-mm recoilless-rifle squad leader as the senior surviving NCO; no officers survived this attack. The firepower of the unit was attrited 68 percent. The unit in this instance could not accomplish its defensive mission and would probably be integrated with survivors of other companies of the regiment. The regiment would be so attrited that it could not accomplish its primary mission of delaying enemy forces for the period of time specified.

The questionnaire data agree closely with the above estimate. They show estimated survivors as: 4 section and squad leaders, 5 company headquarters personnel, and 37 others, including personnel from the rifle squads, the weapons squads, the mortar squads, and the recoilless-rifle squads.

Example 2. In the first defensive position the enemy has withdrawn its main forces from contact and has detonated a 20-kt atomic weapon 1100 yd to the rear of the company. Because of the high values of nuclear radiation present at the company position there will be almost immediate nuclear radiation combat ineffectives. After about 2 hr there would be 42 survivors (21 percent) from the company with an assistant squad leader as senior surviving NCO. The firepower has been attrited by 80 percent.

A count of survivors taken from the questionnaire data shows total survivors to be 44 for this second situation. This compares well with the 42 survivors counted from the field-experiment data.

Example 3. The third atomic attack studied was during the period when the regiment had passed through division MLR and was in division reserve. The enemy launched three 40-kt missiles. The closest GZ to the company was at a distance of 1250 yd. Only 15 survivors remained in the company and their firepower was, of course, negligible. This attrition is probably representative of the effects of this attack on the regiment. There was no possibility of the regiment carrying out its counterattack plans.

The similar situation discussed in the presentation of the questionnaire data indicates that based on the questionnaire results there would be only 8 survivors remaining in the company after this atomic attack.

Example 4. The fourth example of the effects of atomic weapons on the rifle company was taken when the unit was well dug in on the new MLR. Ground zero of an 80-kt weapon was 1700 yd from the unit. Since the troops were well

dug in and were exercising normal procedures for keeping covered the company suffered about 25 percent combat-ineffective personnel and about the same reduction in firepower.

Based on the data derived from the questionnaire the survivors are distributed throughout the six groups of personnel used in the questionnaire. These survivors include the CO, the ExO, 2 platoon leaders, 14 section and squad leaders, etc. The questionnaire data showed 17 percent combat ineffectives as compared to 25 percent combat ineffectives based on the field-experiment data.

In each of these four situations no consideration was given initially to any obscuration of thermal radiation that might be afforded by natural foliage in the areas. The first atomic attack on the unit was reexamined taking into consideration a thermal radiation obscuration factor of 50 percent. This consideration increased the number of survivors from 15 percent to 58 percent and increased the firepower remaining from 32 percent to 51 percent. No consideration has been made here of secondary blast casualties nor has the probability of serious fires been investigated.

BALANCE BETWEEN PROTECTION AND EFFECTIVENESS

The primary reason for protection of infantry troops is to keep them effective so they can accomplish their mission on the battlefield. Their effectiveness is a measure of their ability to accomplish their mission. Yet infantry troops are not necessarily effective when protected from the effects of atomic weapons. The infantry soldier must be able to man his weapon, shift his fire, and move from one position to another to bring fire to bear on the enemy. The moment protective measures become a burden on the individual or on the logistic system the individual is then rendered less effective.

Protection of the man-weapon combination and its associated firepower is the main issue of this memorandum, and the field test and questionnaire were designed to produce quantitative data on this vulnerability. It has been shown how, when troops are aware of what protective measures can do to reduce their vulnerability, these troops can prepare positions that will afford high degrees of protection. The important fact is that these positions can be prepared with equipment presently available to infantry troops. Comparing the last two examples of the effects of atomic attacks on the rifle company, the vast difference in the number of survivors and the amount of surviving firepower is very apparent: 76 percent firepower remaining vs 14 percent. In both cases there was enough thermal radiation at the troop positions to produce immediate burn casualties; however, well dug-in troops in the last example survived to remain an effective unit.

In a future war even though atomic weapons may be used on the battlefield the infantry soldier will also be exposed to conventional artillery fire, air attack, and aerial observation. However, the individual should not be protected from atomic weapons effects in such a manner that he may move about above ground and be safe; if he were to be so protected his effectiveness would be drastically reduced. The present methods of protection from conventional weapons effects provide a high degree of protection from atomic weapons effects. Current doctrine[4,5] on the design and construction of foxholes, weapons emplacements,

observation posts, and command posts is excellent for the purpose of protection on the atomic battlefield. The first and third examples of atomic attacks on the rifle company emphasize the results of lack of well-prepared positions. A unit reduced in firepower to 14 percent or 30 percent of its capability has its effectiveness in accomplishing its mission reduced proportionately. However, weapons emplacements and command posts should not be constructed so that they will ensure personnel survival if they are in the immediate proximity of the point of detonation. Such doctrine would be as fallacious as the requirement for individual troops to move about above ground at all times. The major concern is that where there is a chance of survival the probability of survival must be high.

The most urgent need of infantry troops on the atomic battlefield is speed. They must be able to prepare their positions in the least possible time to reduce their exposure. There is a limit to the speed with which a company can dig its emplacements with present numbers of troops and equipment; this limit must be changed with additional digging aids. However, once these emplacements have been prepared the troops must be able to use them for protection from atomic weapons effects when disengaged from the enemy as well as for protection from conventional weapons effects during the defense of the position. Unless a unit is under artillery fire when not engaged, there is a tendency for troops to be out of the emplacements performing administrative and supply tasks. Some form of early warning of an atomic attack must be made available to these infantry troops if they are to derive the maximum benefit of the protection afforded them by their emplacements. A 1- or 2-min warning would be sufficient to enable close to 100 percent of the unit to take cover and have a relatively high degree of protection from atomic weapons effects.

There is another means of passive individual and unit protection that must be emphasized. This is the use of natural cover for protection against thermal radiation. In the first example of the effects of an atomic detonation on the rifle company it has been shown that a 50 percent shading of the company area increased the survivors from 15 percent to 58 percent and the firepower from 32 percent to 51 percent. The mobility of a rifle company is the speed of movement of the man-weapon-ammunition combination. Tree blowdown creates abatis that reduce the mobility of a rifle company to some extent; however, it is believed that the shading that foliage provides to the infantryman may sometimes offer considerable bonus protection if the unit is close enough to GZ to receive damaging thermal effects but far enough away to have small secondary blast effects. This may well not be true for armored units since although the vehicles provide shading for the crews, tree blowdown would drastically reduce armored mobility.

In addition to construction aids the Army should consider several urgently needed items of protection for the individual soldier. Such items as short capes and visors for the helmet, face masks, gloves, etc.—items of personal equipment to protect exposed skin surfaces—should be made readily available to troops today.

The data of both field test and questionnaire are replete with instances in which company headquarters, platoon headquarters, and section leaders are the most exposed elements in the unit. This is to be expected in view of their very function of supervision, direction of activities, etc. Yet these make up the key

personnel in the chain of command. High rates of surviving firepower would eventually be vitiated by the lack of decision and direction. Command posts at all levels of command must be protected. It then follows that the communications system will be equally as protected since its key personnel and equipment are usually located with the main elements of the command system. Since the intelligence channels follow the communication channels they also would receive the same degree of protection.

It is, however, logical to assume that even if a unit protected to the optimum extent were subjected to damaging effects of an atomic detonation, it would suffer attrition to some of its elements. It is of extreme importance that the surviving members of the unit be able to exploit, to the best advantage, the surviving firepower. If the command and communications systems have been attrited the time factor in reorganization could mean the difference between success and failure. It is therefore necessary that reorganization be accomplished in minimum time. The surviving senior member of the group must be readily capable of discovering that he is now in command, must make this known to other survivors, and must then direct the survivors in their reorganization. He must be capable of reaching the last rifleman on the far flank to most effectively direct his efforts. This requirement suggests an addition to the present company communication system in the form of aided communications down to riflemen level.

In view of the large number of combat ineffectives expected among supervisory personnel in an atomic attack, it is imperative that increased emphasis be placed on training individual soldiers to carry on their respective duties regardless of available supervision.

CONCLUSIONS*

1. Foxholes with heavy overhead cover constructed according to present doctrine provide a high degree of protection against atomic attack, but the time now required to prepare such positions is dangerously long.

2. It took about $1\frac{1}{2}$ hr from the time of arrival in a defense area for the company to dig foxholes deep enough to provide emergency below-ground cover for the whole unit. During this time about 95 percent of the personnel was fully exposed.

3. Assembly areas took about 4 hr to prepare, during which time the percentage of men fully exposed dropped steadily from 100 percent down to a level of 10 percent for occupation of the completed area through the night.

4. Hasty defensive positions took about 3 hr to prepare, during which time the percentage of men fully exposed dropped steadily from 100 percent down to a level of 15 percent for occupation of the completed position through the night.

5. Deliberate defensive positions took about 12 hr to prepare, during which time the percentage of men fully exposed dropped steadily from 100 percent down to a level of 30 percent for daylight occupation or 15 percent for night occupation.

6. Reduction of preparation time by one-third will on the average reduce the percentage of men fully exposed by one-quarter.

*Conclusions on position preparation refer to preparation while out of direct contact with the enemy.

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CPWC/TRC November 3, 1999

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ATTN: OCQ/MR WILLIAM BUSH

SUBJECT: DOCUMENT CHANGES

The Defense Threat Reduction Agency Security Office has performed a classification/distribution statement review for the following documents:

DASA-2519-1, AD-873313, STATEMENT A
DASA-2536, AD-876697, STATEMENT A
DASA-2519-2, AD-874891, STATEMENT A
DASA-2156, AD-844800, STATEMENT A
DASA-2083, AD-834874, STATEMENT A
DASA-1801, AD-487455, STATEMENT A
POR-4067, AD-488079, STATEMENT C, ADMINISTRATIVE/OPERATIONAL USE
~~DASA-2228-1, AD-851256, STATEMENT~~ C, No Target
ADMINISTRATIVE/OPERATIONAL USE only chged from SA to adm/oper.
RAND-RM-2076, AD-150693, STATEMENT D, ADMINISTRATIVE/OPERATIONAL USE
AD-089546, STATEMENT A, ~~ADMINISTRATIVE/OPERATIONAL USE~~ * ST-A Jun 65
DASA-1847, AD-379061, UNCLASSIFIED, STATEMENT C, ADMINISTRATIVE/OPERATIONAL USE
~~RAND-RM-4812-PR~~, ELEMENTS OF A FUTURE BALLISTIC MISSILE TEST PROGRAM, UNCLASSIFIED, STATEMENT C, ADMINISTRATIVE/OPERATIONAL USE 370168 Conf
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Per A. Jarrett 23 Nov 99

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